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Green Wave Sleep Scheduling Algorithm in Wireless Network

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Abstract—The nodes in a wireless network to sleep periodically can save energy, it also incurs higher latency and lower throughput. We consider the problem of designing optimal sleep schedules in wireless networks, and show that finding sleep schedules that can minimize the latency over a given subset of source-destination pairs is NP-hard. We proposed green-wave sleep-scheduling (GWSS)—inspired by synchronized traffic lights—for scheduling sleep-wake slots and routing data on duty-cycling wireless adhoc networks. We also derive a latency lower bound given by d + O(1/p) for any sleep schedule with a required active rate (i.e., the fraction of active slots of each node) p, and the shortest path length d. We offer a novel solution to optimal sleep scheduling using green-wave sleep scheduling (GWSS), inspired by coordinated traffic lights, which is shown to meet our latency lower bound (hence is latency-optimal) for topologies such as the line, grid, ring, torus and tree networks, under light traffic. For high traffic loads, we propose non-interfering GWSS, which can achieve the maximum throughput scaling law given by T(n,p) = Â¿(p/Â¿n) bits/sec on a grid network of size n, with a latency scaling law D(n,p) = O(Â¿n) + O(1/p).

Keywords—Wireless Network, Sleep Scheduling, Greenwave, High Latency, Low Throughput.

I. INTRODUCTION

The periodic sleepscheduling of RF transceivers of nodes in a wireless or sensor network can significantly reduce energy consumption. This paper sheds light on the fundamental limits of the end-to-end data delivery latencyand the per-flow throughput in a wireless network with multiple interfering flows, in the presence of "coordinated" duty cycling. We propose greenwavesleepscheduling (GWSS) - inspired by synchronized traffic lights - for schedulingsleep-wake slots and routing data in a duty cycling wireless network, whose performance can approach the aforementioned limits.

Particularly, we derive a general latency lower bound and show that GWSS is latency optimal on various structured topologies, such as the line, grid and the tree, at low traffic load. For an arbitrary network, finding a solution to the delay-efficient sleepscheduling problem is NP-hard. But for the 2D grid topology, we show that a non-interfering construction of GWSS is optimal in the sense of scaling laws of latencyand capacity. Finally, using results from percolation theory, we extend GWSS to random wireless networks, where nodes are placed in a square area according to the Poisson point process.

Aided by strong numerical evidence for a new conjecture on percolation on a semi-directed lattice that we propose, we demonstrate the latency optimality of GWSS on a random extended network, i.e., for an area-n random network with unit-density-Poisson distributed nodes, and a node-active (duty-cycling) rate p, GWSS can achieve a per-flow throughput scaling of $T(n, p) = \Omega(p/\sqrt{n})$ bits/sec andlatency $D(n, p)$ scaling of $O(\sqrt{n}) + O(1/p)$ hops/packet/flow.

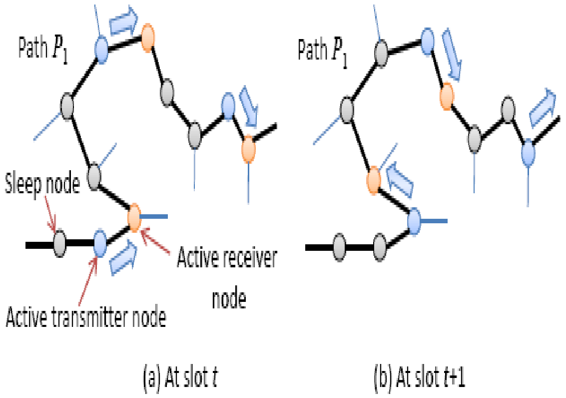
Idle listening (without reception or transmission) in radio transceivers of wireless networks is a primary cause of energy consumption, because the power consumption of a transceiver in “listening” state is comparable to that in the “receive” state. Researchers have proposed “sleep scheduling” (or *duty cycling*) of radio transceivers to conserve battery energy, by occasionally turning the transceivers OFF and then back ON in a controlled fashion. While duty cycling conserves energy, it suffers from the cost of incurring higher data delivery latency and lower data throughput.

The goal of this work is to investigate the fundamental limits of latency and throughput with duty cycling nodes in a wireless network with interfering flows, and to devise constructive sleep scheduling algorithms whose performance can approach those fundamental limits.

II. METHODOLOGY

- Our proposed algorithm green wave sleep scheduling (GWSS) is developing with the intention to control the congestion drastically over the data transmission in the wireless networks.

- This system is an inspired concept taken from the traffic signals that are used in the heavy traffic roads in the big cities around the world.
- I.e. our algorithm finds the different channels to transmit its data to the destination nodes by check the buffer level and data storage measurement for the particular route and open the transmission for that route to forward the huge data to the n nodes.



(a) At slot *t* (b) At slot *t*+1

FIGURE 1: ARCHITECTURE DIAGRAM

- This green wave sleep scheduling (**GWSS)** - inspired by synchronized traffic lights - for scheduling sleep-wake slots and routing data in a duty cycling wireless network, whose performance can approach the aforementioned limits.
- We extend GWSS to random wireless networks, where nodes are placed in a square area according to the Poisson point process. Aided by strong numerical evidence for a new conjecture on percolation on a semi-directed lattice that we propose, we demonstrate the latency optimality of GWSS on a random extended network.
- i.e., for an area-n random network with unit-density-Poisson distributed nodes, and a node-active (duty-cycling) rate p, GWSS can achieve a per-flow throughput scaling of $T(n, p) = \Omega(p/\sqrt{n})$ bits/sec and latency $D(n, p)$ scaling of $O(\sqrt{n}) + O(1/p)$ hops/packet/flow.

III. MODULE DESCRIPTION

This GWSS algorithm has been divided into several modules to solve the problem of data congestion and improved traffic management over the wireless networking system.

1) **GWSS Simulation Model Setup.**
2) **GWSS Node Selection.**
3) **Traffic Controller using GWSS.**
4) **Performance Results**

1. GWSS Simulation Model Setup

The module has two external input channels from other nodes, In-x and In-y, and two external output channels to other nodes Out-x and Out-y. Each router's external input channel is connected to single-flit input buffers, In-x-buffer and In-y-buffer. The node's processor sends to the router the new messages generated by the nodes executing the parallel application through an internal input channel, named in channel. The processor receives the flits addressed to it from the extraction units, interfacing the processor with external input channels. The router is provided with a switch connecting all input channels (both internal and external) to all external output channels

2. GWSS Node Selection

This module mainly deals with the nodes (X1, X2) selection for the new data transmission generated by the source is stored inside the data header. We select more number of destination nodes with constraint for one allowable node. Fresh-message-queue and sent to a one-flit input buffer, and that can be transmitted to the traffic controller that are placed in the common gateway for all the transmission host nodes to pre-transmit data packets.

The retransmission mechanism is based on negative acknowledges (NACKs) sent by the nodes that drop a flit. Thus, flits are not immediately deleted from the Fresh-message-queue as soon as they are placed in the Unacked flits buffer. The Unacked-flits buffer is not a standard queue, that is, it is not served with first-in first-out logic. A flit can be fetched from the headers flits buffer when needed according to the packet weights of the data that are transmitted from the host nodes.

3. Traffic Controller using GWSS

In Traffic controller the host nodes are transmit the packets can rideon either green wave depending on the direction (assuming that the routes are known), and can be forwarded with minimal latency. In a nutshell, this constitutes green wave sleep scheduling (GWSS). It is straightforward to show that GWSS meets the latency lower bound on structured network topologies such as the line, ring, grid, torus, and tree topologies, hence proving GWSS to be latency-optimal on these topologies.

We have shown that on large networks arranged in specialized topologies as well as random extended Poisson networks, GWSS achieves almost the same end-to-end latency as non sleep- scheduled networks for moderate values of *p*, and that it is primarily governed by the shortest path distance *d* between the source and the destination. We will also delineate the full tradeoff space of throughput versus latency scaling in duty cycling random extended wireless networks. We are continuing to work on an analytical proof of Conjecture Finally, we are working on extending GWSS for energy-efficient latency-optimal sleep scheduling on finite networks with arbitrary graph topologies.

Here, this system showed some tremendous data transfer and improved congestion controller for the n number of nodes. But for our simulation setup we are used line topology.

4. Results

The experimental results showed the energy efficient latency optimal sleep scheduling on finite networks with arbitrary topologies**.**

IV. CONCLUSION

We have shown that on large networks arranged in specialized topologies as well as random extended Poisson networks, GWSS achieves almost the same end-to-end latency as non sleep- scheduled networks for moderate values of p, and that it is primarily governed by the shortest path distance d between the source and the destination. At the same time, if only a small number of packets are being sent around a large network, the same $d + O(1/p)$ latency can be more or less maintained for each packet, without increasing p. So, under light traffic, increasing the load initially will not result in an increase in energy consumption. Moreover, in the low load Scenario, if the network is large (i.e., the shortest path lengths d for all S-D pairs are large), then sleep scheduling can save significant energy with only an additional $O(1/p)$ _ d delay for each transmission. We will also delineate the full tradeoff space of throughput versus latency scaling in duty cycling random extended wireless networks. We are continuing to work on an analytical proof of Conjecture 1. Finally, we are working on extending GWSS for energy-efficient latency-optimal sleep scheduling on finite networks with arbitrary graph topologies.

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